BRODSKI RASHLADNI UREĐAJI

BS 3

Uvod

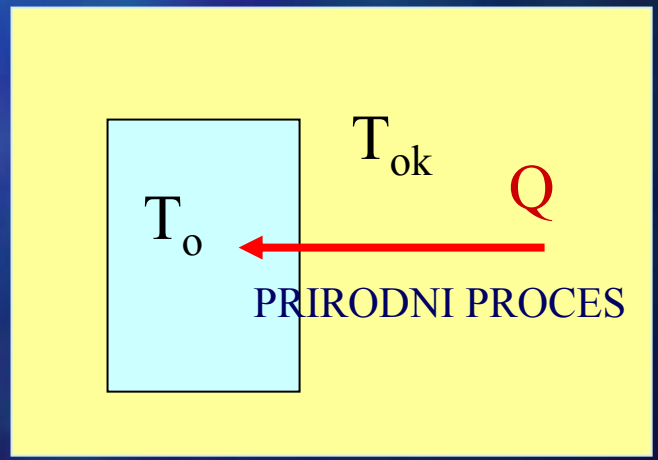
Rashladne tvari

CILJ

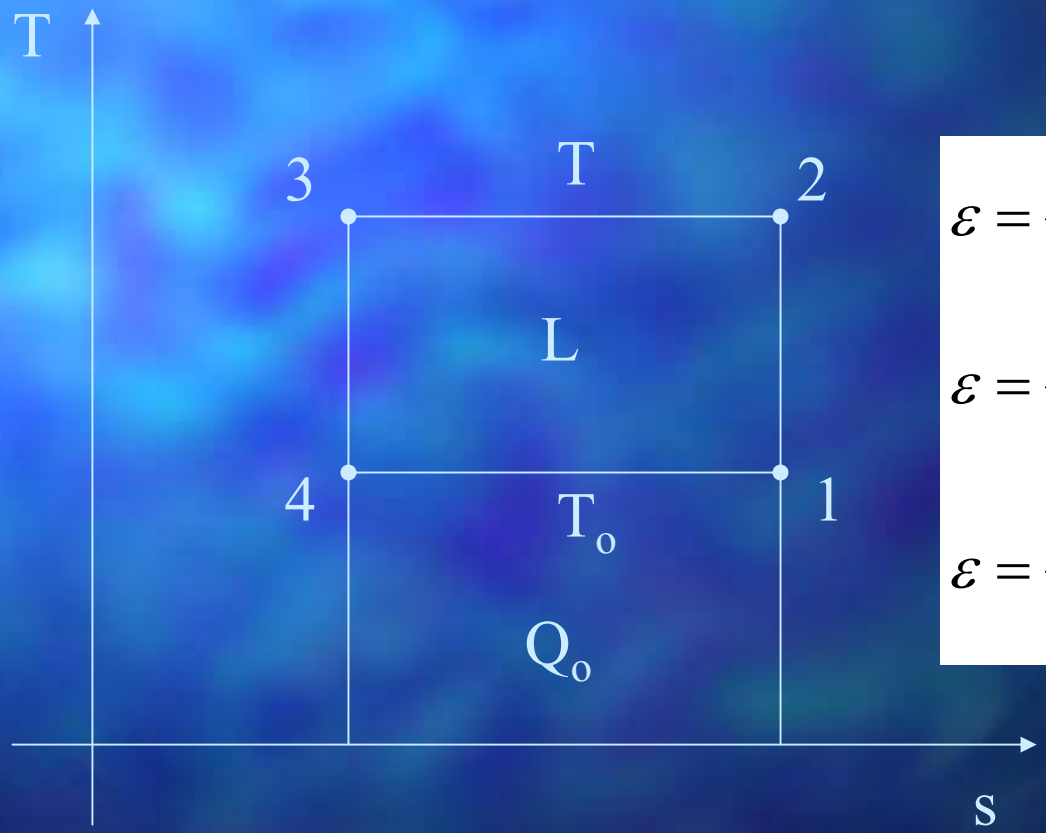
- sniziti temperaturu prostora (fluida) ispod temperature okoline
- suprotno osnovnim termodinamičkim (prirodnim, iskustvenim) zakonima
- tehnološki proces

$T_o < T_{ok}$

Bitno: odrediti rashladni učin, tj. toplinu koju treba odvoditi



Idealni proces



$$\varepsilon = \frac{Q_o}{L}$$

$$\varepsilon = \frac{T_o \cdot \Delta s}{(T - T_o)\Delta s}$$

$$\varepsilon = \frac{T_o}{T - T_o}$$

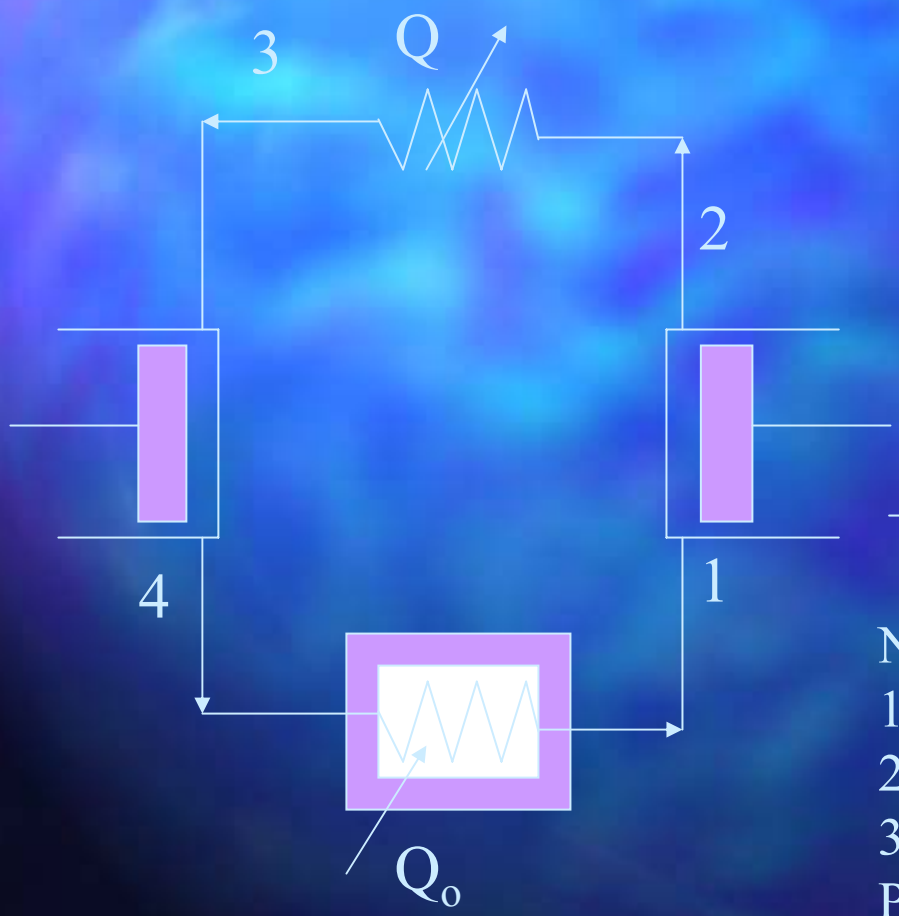
TIPOVI RASHLADNIH UREĐAJA

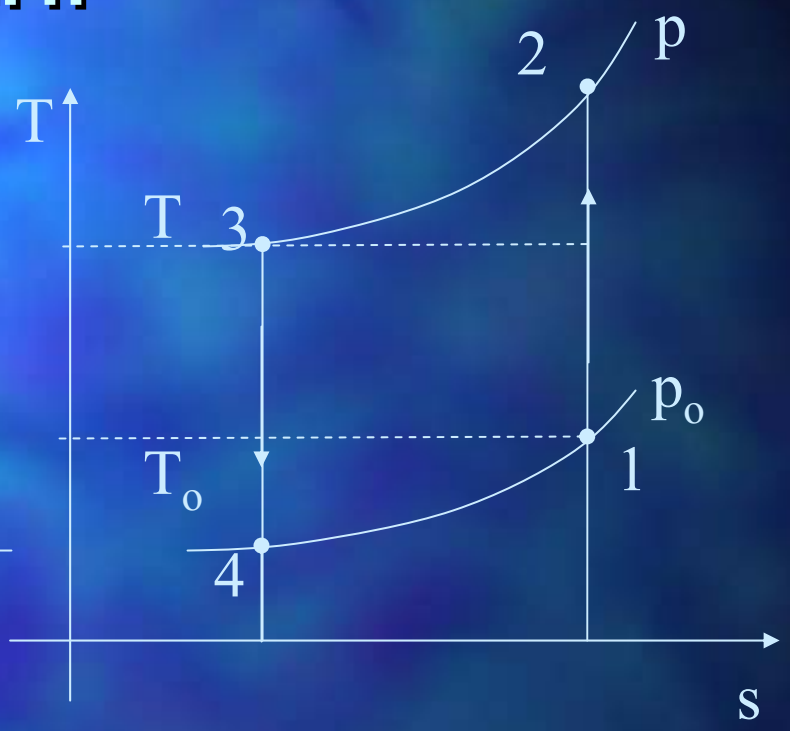
- EJEKTORSKI
- APSORPCIJSKI
- ZRAČNO-KOMPRESORSKI
- **PARNO-KOMPRESORSKI**
- (TERMOELEKTRIČNI)

KOMPRESORSKI - RAZVOJ

- zračni kompresorski
- parni komp. – ekspanzijski cil.
- ekspanzijski ventil
- suhi usis
- pothlađivač kondenzata

Zračni



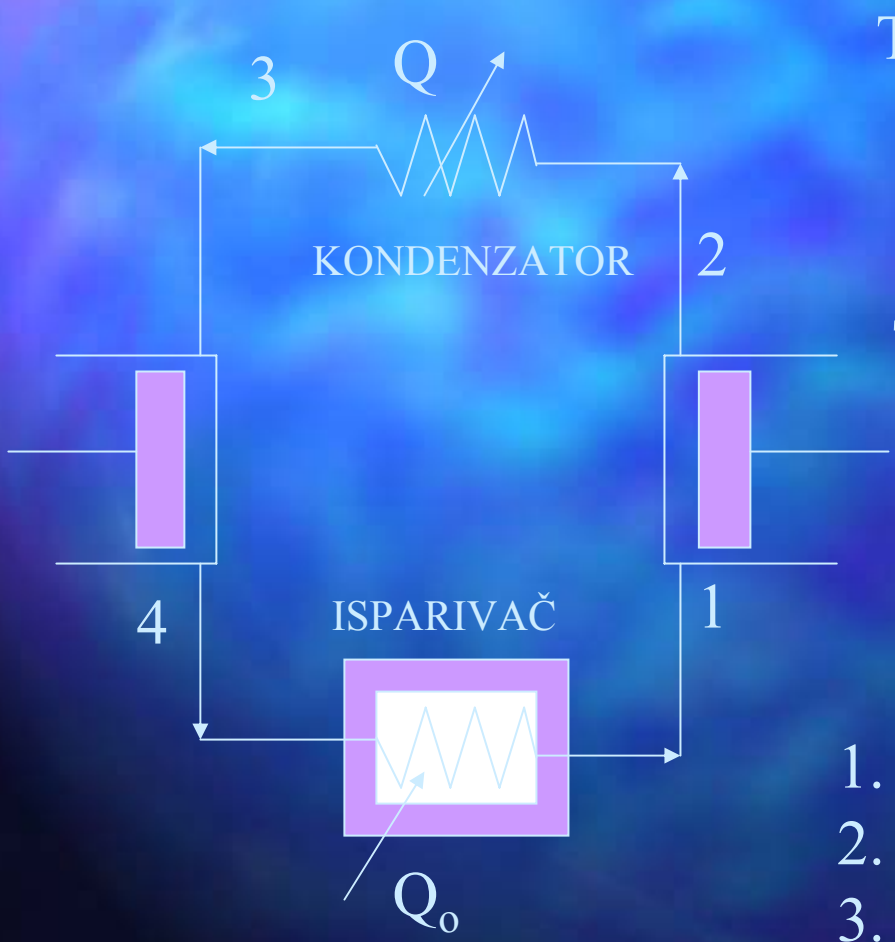


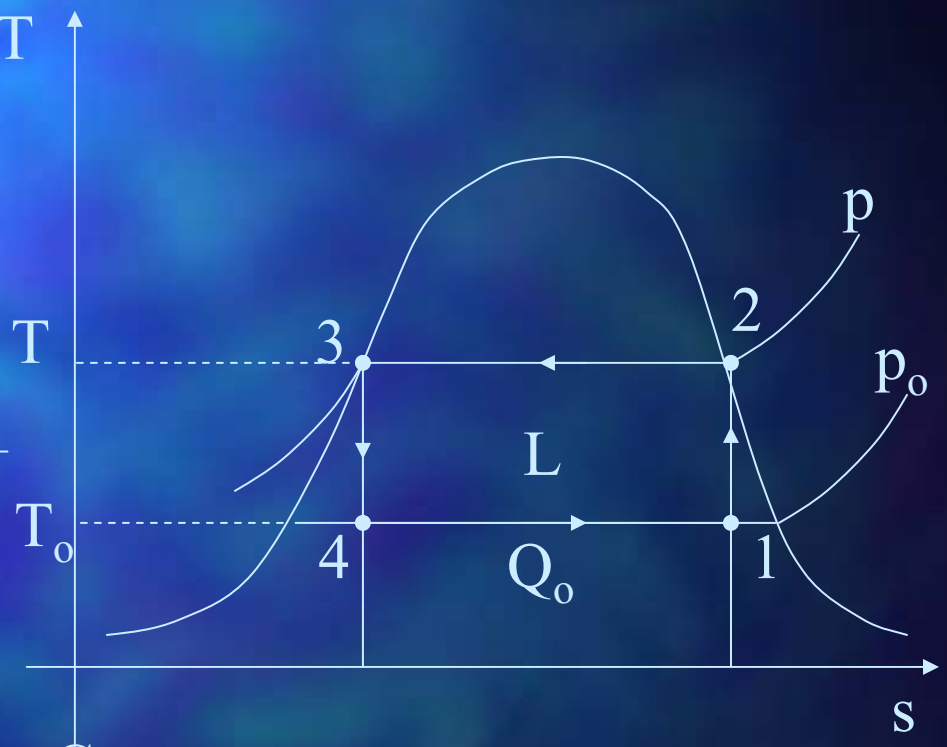
Nedostaci:

1. udalajvanje od Carnot-ovog procesa
2. mali sp. toplinski kapacitet
3. iskoristivost

Poboljšanje: dvostepenom kompresijom

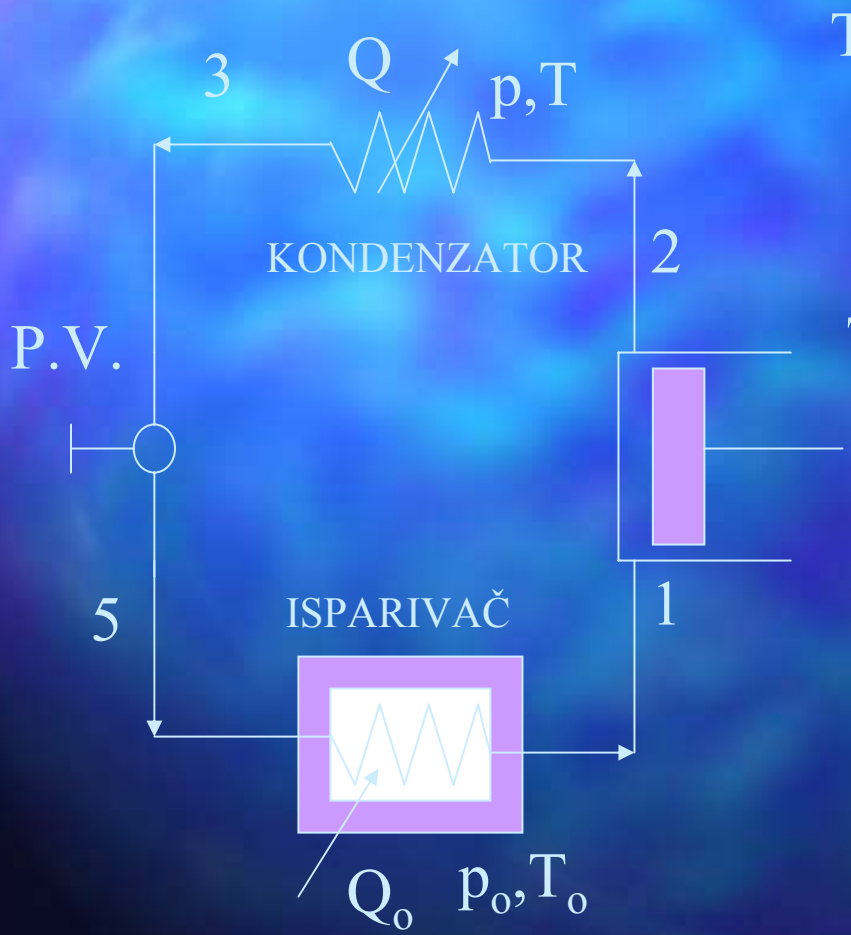
Parni (u zasićenom području)

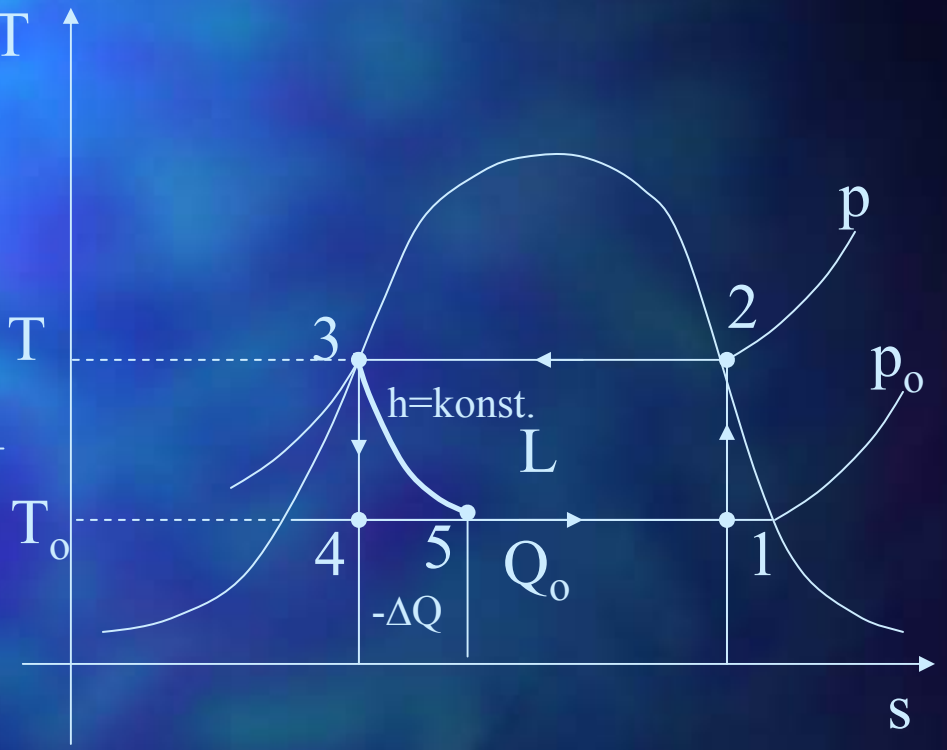




1. Carnot
2. veći toplinski kapacitet
3. usis mokre pare

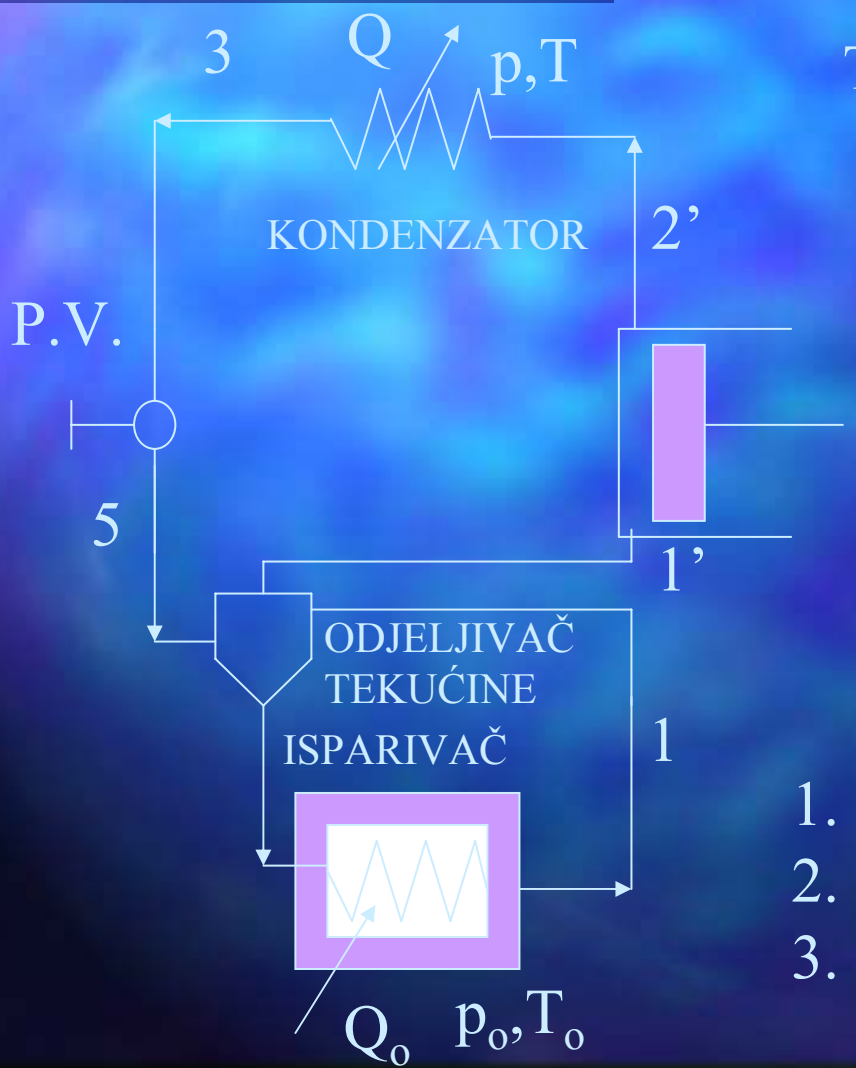
Parni (s prigušnim ventilom)

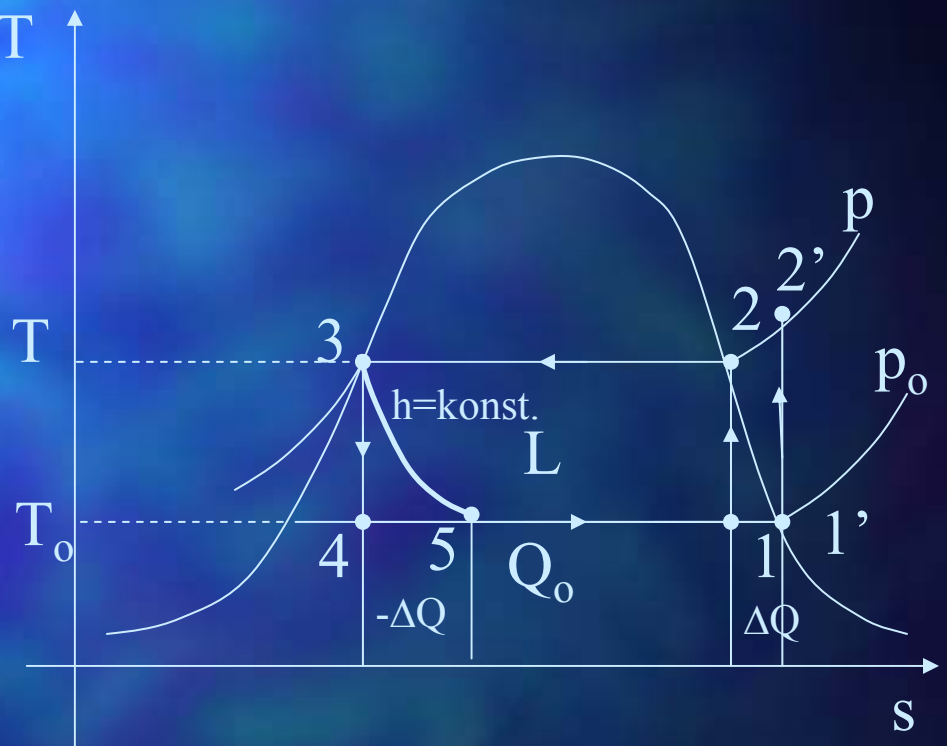




1. manji rashladni učin
2. jednostavan prigušni ventil

Parni (u pregrijanom području)

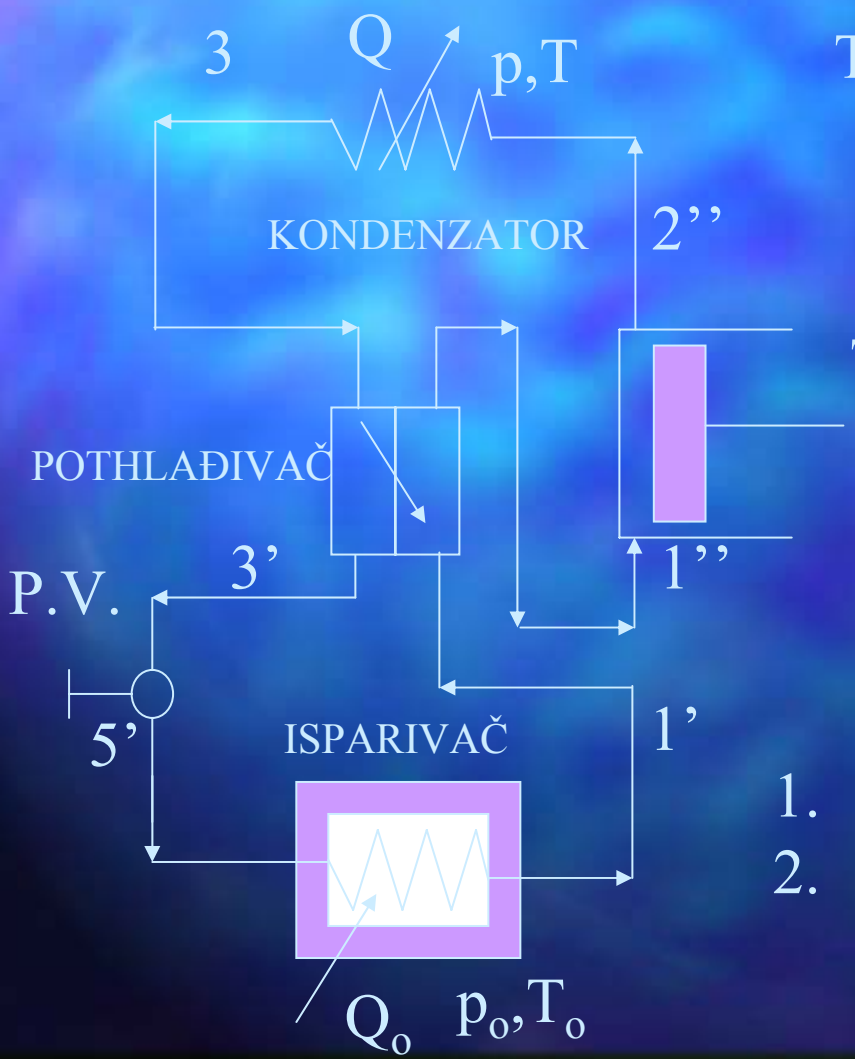


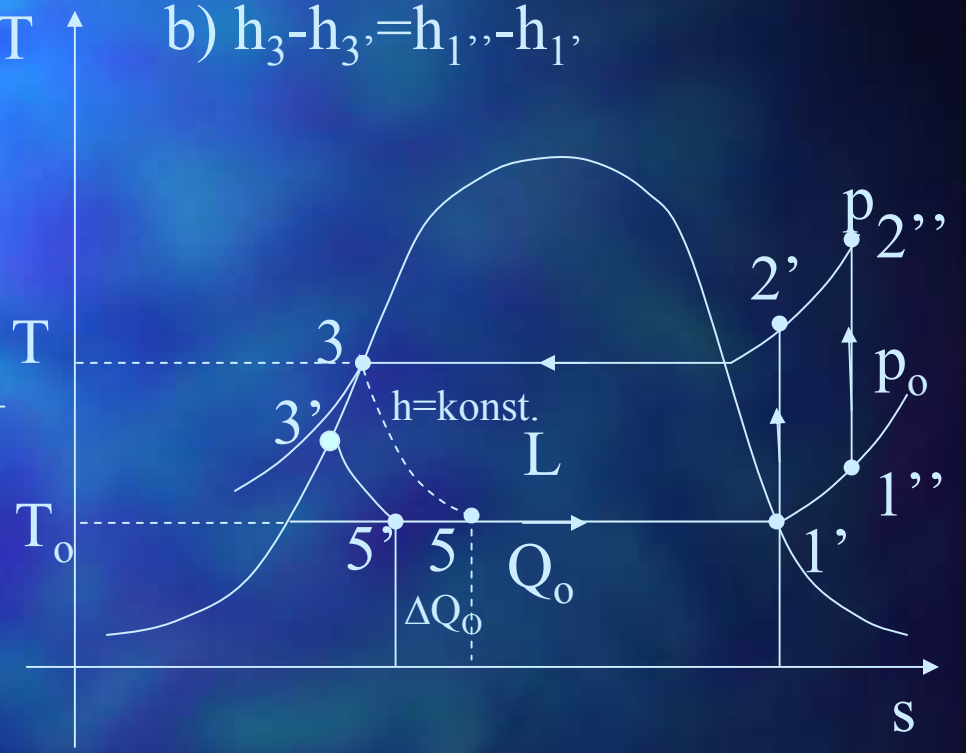


1. veći utrošeni rad
2. veći rashladni učin
3. suhi usis

Parni (s pothlađivačem kondenzata)

Napomena: a) 3’ na krivulji
b) $h_3-h_{3'}=h_{1''}-h_{1'}$





1. povećanje rashladnog učina
2. još veće udaljavanje od Carnota

Daljnji razvoj

- dvostepena kompresija s međuhlađenjem
- dvostepena kompresija s odjeljivačem i jednim prigušnim ventilom
- dvostepena kompresija s odjeljivačem i dva prigušna ventila
- ne radi se ako nije potrebno

OSNOVNI DIJELOVI

- KOMPRESOR
- KONDENZATOR
- PRIGUŠNI (EKSPANZIJSKI) ELEMENT
- ISPARIVAČ
- sušilac, zbog eksploatacijskih razloga

RADNE TVARI

- Od XIX st.: etileter $\Rightarrow$dimetileter $\Rightarrow$ NH_3 $\Rightarrow$ CO_2 $\Rightarrow$$SO_2$ $\Rightarrow$ N_2O $\Rightarrow$ etan (etilen, propan, izobutan) $\Rightarrow$ klorometan, brodski uređaji - CO_2 i NH_3 $\Rightarrow$ FREONI
- freoni - derivati metana i etana (F,Cl,Br)
- R-12 i R-22
- danas: R-12 $\Rightarrow$R-22, azeotropne smjese, CO_2 i NH_3

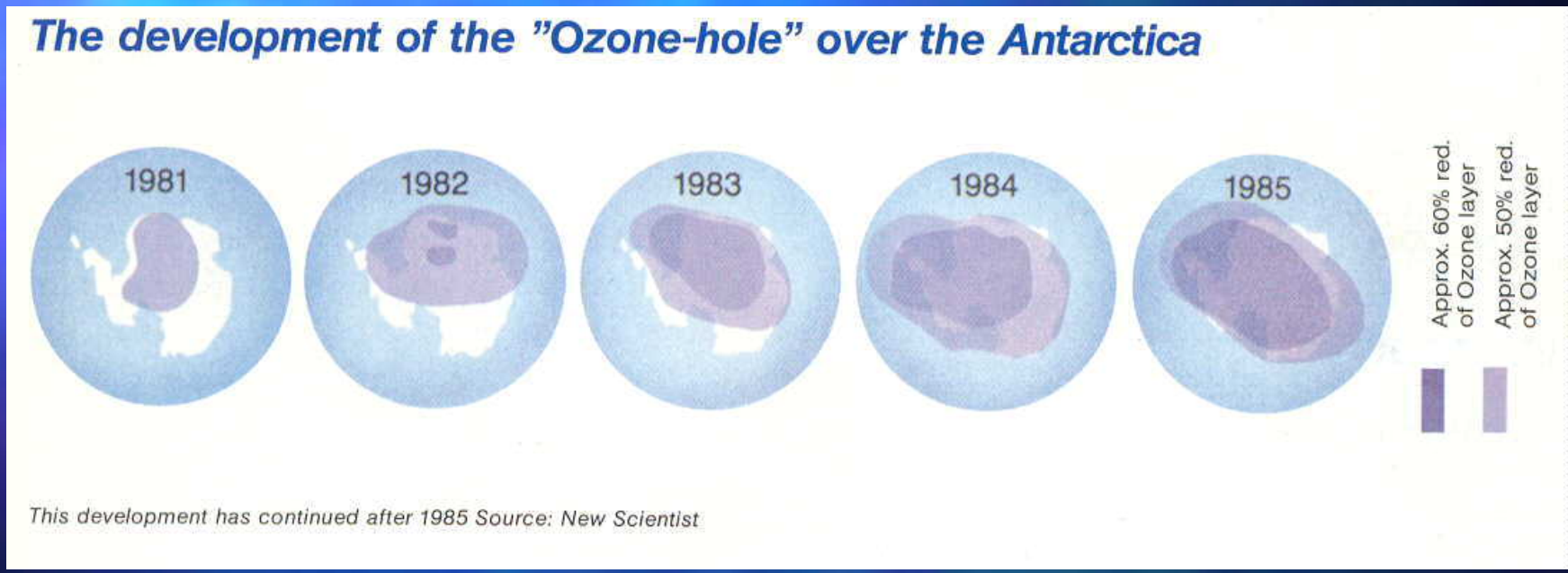
MJERE PREDOSTROŽNOSTI

- TLAKOVI U SUSTAVU
- ekspandira na atm. tlak – niske temperature – smrzotine
- otežano disanje, pad krvnog tlaka, nesvjestica, drhtanje, oštećenja jetre, iritacija kože
- kemijske reakcije – otrovnost (opasan dodir s kožom, sluznicom, očima)

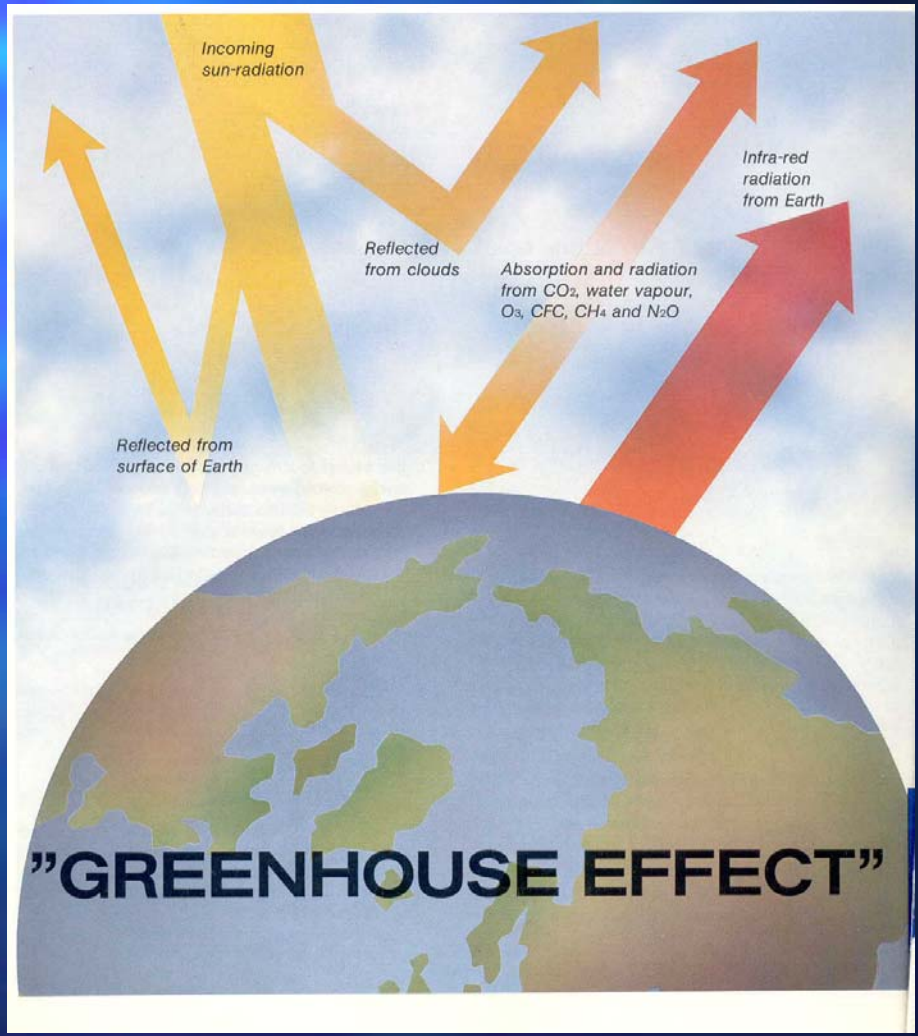
OKOLIŠ

- ozonski omotač
- efekt staklenika - globalno zatopljenje
- zamjena R-12 s R-22
- R-22 ima 5%-tni štetni potencijal R-12

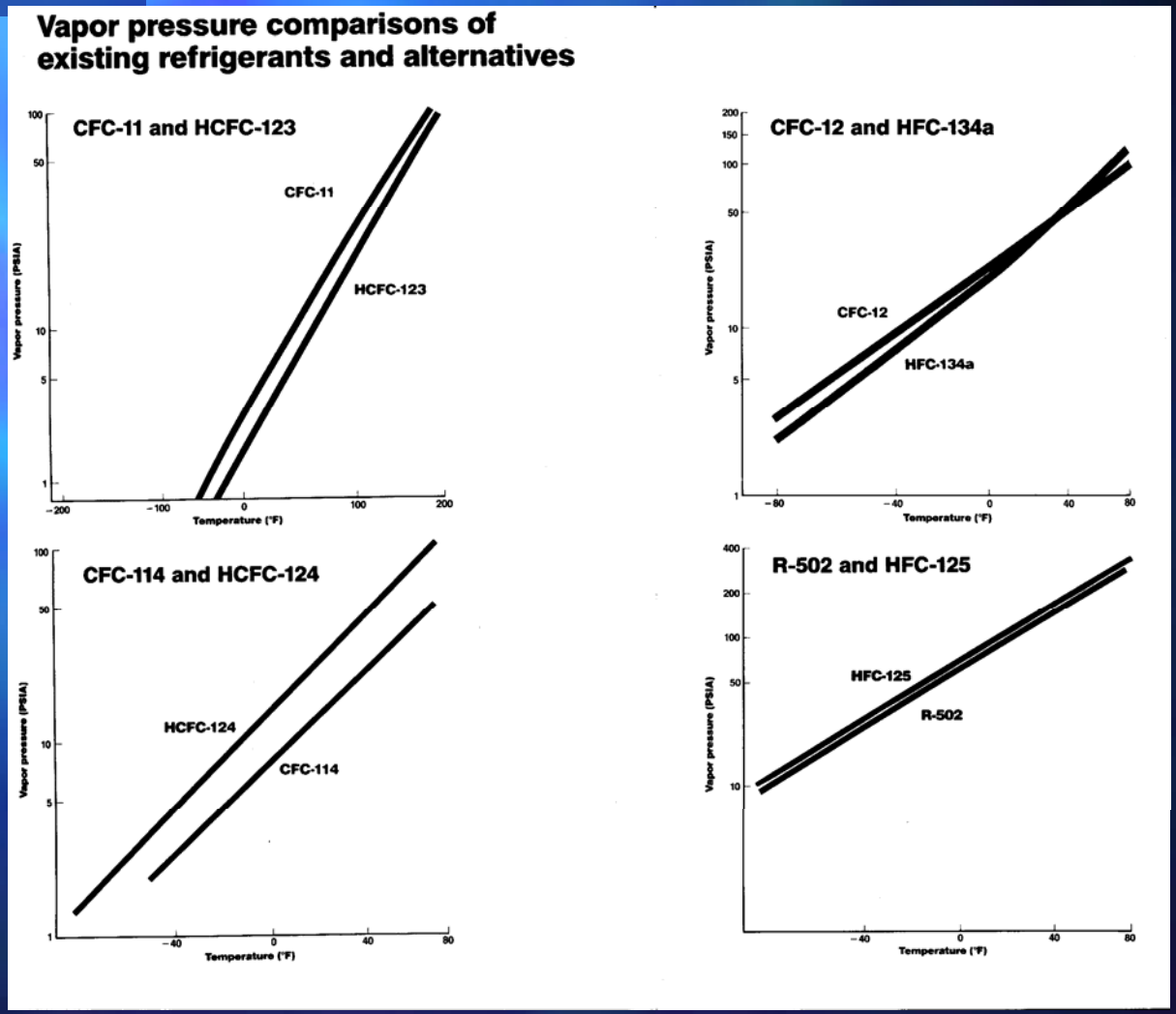
OKOLIŠ


The development of the "Ozone-hole" over the Antarctica
1981
1982
1983
1984
1985
Approx. 60% red. of Ozone layer
Approx. 50% red. of Ozone layer
This development has continued after 1985 Source: New Scientist

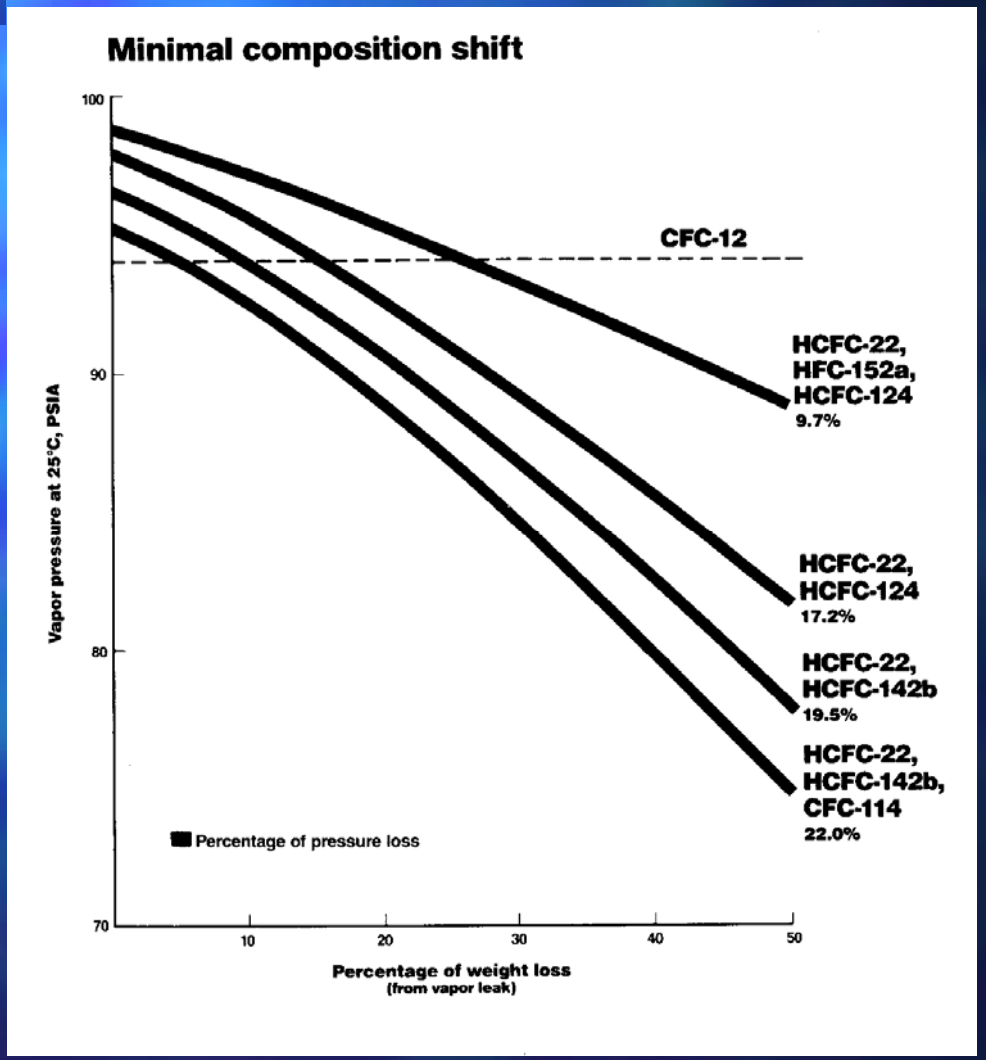
OKOLIŠ


Incoming sun-radiation
Infra-red radiation from Earth
Reflected from clouds
Absorption and radiation from CO_2, water vapour, O_3, CFC, CH_4 and N_2O
Reflected from surface of Earth
"GREENHOUSE EFFECT"

Zamjenska sredstva



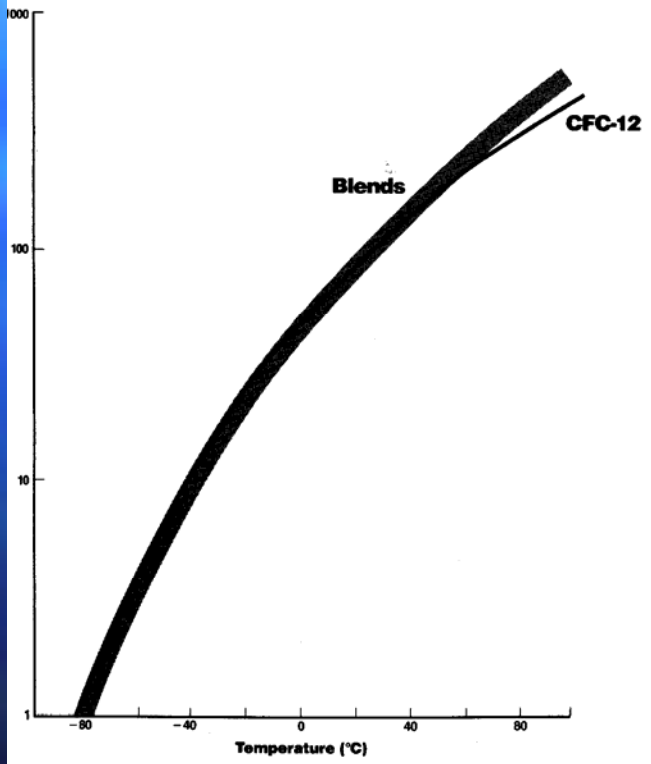
Zamjenska sredstva



Zamjenska sredstva

Blends for CFC-12 aftermarket

Vapor pressure comparisons



Theoretical cooling capacity and energy efficiency improvements

	CFC-12	Blend (range)
Cooling capacity (relative CFC-12)	1.0	0.95–1.05
Energy efficiency (COP)	2.10	2.16–2.17
Evaporator pressure (PSIA)	19	16–18
Compressor discharge pressure (PSIA)	196	195–215
Compressor discharge temperature (°F)	158	185–190

Test conditions: Condenser 130°F, Sub-cooling 0, Evaporator −10°F, Superheat 5°F

- Patented multi-component blends, can contain: HCFC-22, HFC-152a, CFC-114, HCFC-124 and others
- Soluble with commercial oils
- Minimal retrofit expected
- Applications may include medium temperature food cases, vending machines, auto a/c and appliances
- Possible OEM candidates

Zamjenska sredstva

Physical Data	GRADES METRIC UNITS	11 Trichloro-fluoromethane	12 Dichlorodi-fluoromethane	22 Chlorodi-fluoromethane	502
Chemical Formula		CCl_3F	CCl_2F_2	$CHClF_2$	Azeotrope
Molecular Weight		137·38	120·93	86·48	111·6
Boiling Point at 1 atm	°C	23·8	−29·8	−40·8	−45·6
Freezing Point	°C	−111	−158	−160	
Critical Tempetature	°C	198	112	96	90·1
Critical Pressure	atm kg/sq cm abs	43·2 44·98	40·6 42·0	48·7 50·3	42·1 43·5
Critical Volume	cc/mol	247	217	164	199·5
Critical Density	g/cc	0·554	0·558	0·525	0·529
Specific Heat of Liquid at 30°C	cal/g/°C	0·208	0·236	0·335	0·30
Specific Heat of Vapour at Constant Pressure (1 atm at 30°C)	cal/g/°C	0·137	0·148	0·152	0·168
Ratio of Specific Heats (Cp/Cv) at 1 atm and 30°C		1·136	1·136	1·184	1·133
Density of Liquid at 30°C	g/cc	1·464	1·292	1·175	1·218
Density of Saturated Vapour at boiling point	g/l	5·85	6·33	4·82	6·032
Latent Heat of Vaporisation at boiling point	cal/g	43·51	39·47	55·92	42·47
Thermal Conductivity of Liquid at 20°C	J/cm/sq cm/s/°C	0·000911*	0·000725*	0·000901*	0·000636
Thermal Conductivity of Vapour at 30°C (1 atm)	J/cm/sq cm/s/°C	0·000083	0·000102*	0·000117	0·000224
Surface Tension at 25°C	dynes/cm	19	9	9	8
Viscosity of Liquid at 30°C	Centipoise	0·405	0·251	0·229	0·24
Viscosity of Vapour at 1 atm and 30°C	Centipoise	0·0111	0·0127	0·0131	0·013
Solubility of Water in Refrigerant	wt % at 30°C 0°C	0·013 0·0036	0·012 0·0026	0·15 0·060	0·022
Solubility of Refrigerant in Water at 1 atm and 25°C	wt %	0·11	0·028	0·30	
Relative di-electric strength at 1 atm and 23°C (Nitrogen = Q)		3·1	2·4	1·3	2·34
Di-electric constant, liquid. Temperature in °C		$2·28^{29}$	$2·13^{29}$	$6·11^{24}$	
Di-electric xonstant, vapour (0·5 atm). Temperature in °C		$1·00197^{26}$	$1·0016^{29}$	$1·0035^{25:4}$	

** Figures taken from a review of the existing data by R. W. Powell ("Modern Refrigeration" December, 1956).*

KOMPRESORI

- **stapni**
- vijčani
- rotacijski (s ekscentričnim rotorom, s lamelama)
- turbokompresori

STAPNI KOMPRESORI

- **otvoreni** (poluotvoreni) i hermetički
- jedno- i **višecilindrični**
- **jednoradni** dvoradni
- **jedno**- i višestepeni

KONDENZATOR

- zračni i **vodom hlađeni (morem)**
- cijevni izmjenjivač topline
- posuda pod tlakom - sigurnosni ventil
- nivokazno staklo - pipci, manometar
- odzračni ventil
- regulacijski ventil vode - presostatski ili termostatski

PRIGUŠNI ELEMENTI

- kapilara
- ventil konstantnog tlaka
- termo-ekspanzijski (TEV) - s unutarnjim i vanjskim izjednačavanjem tlaka, s pilot ventilom
- elektronski upravljani (elektromotorni) – elektroekspanzijski ventil

Kapilara

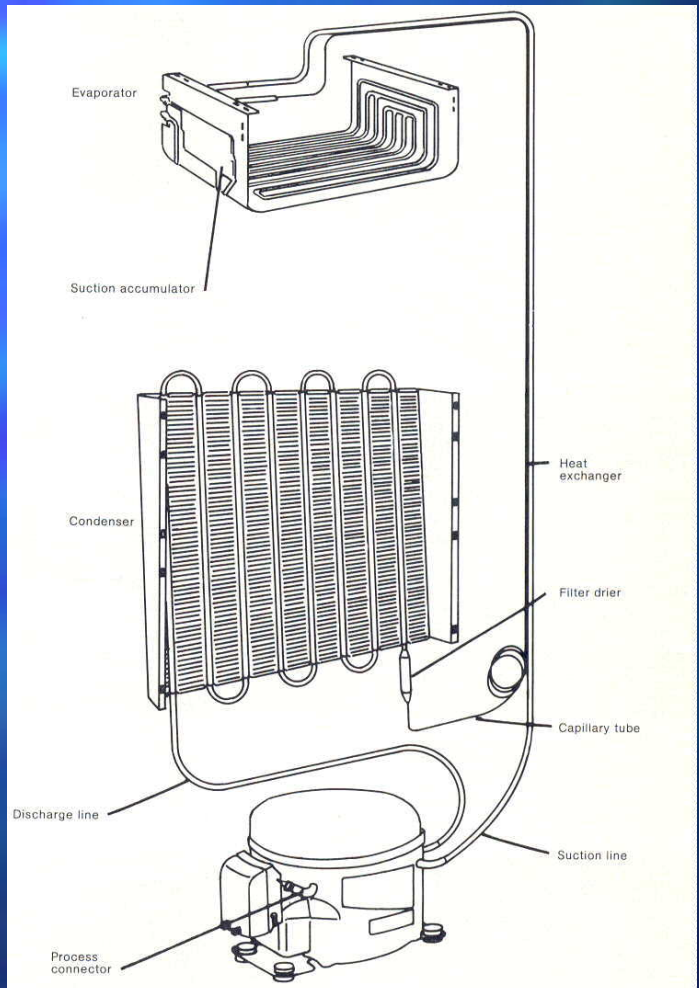


Fig. 1 Hermetic refrigerating system

TEV

- s unutarnjim izjednačavanjem tlaka
- s vanjskim izjednačavanjem tlaka

TEV

ISPARIVAČ

- zrak, voda, rasolina, plin (teret-LPG)
- suhi, polumokri ili mokri
- prirodna ili prisilna cirkulacija zraka
- hlađenje ili zamrzavanje